CLAIMS

1. A monitoring unit [10] for monitoring the condition of a semi-permeable membrane [24], the monitoring unit [10] comprising a flow chamber [12] having an inlet for permitting ingress of a feed fluid into the flow chamber [12], the arrangement being such that the membrane [24] is at least partly supported in the flow chamber [12]: at least one fluid outlet [18] arranged in fluid communication with the flow chamber [12] for permitting egress of fluid from the monitoring unit [10] after having passed through the membrane [24]; and an inspection window [20] for permitting visual inspection of the semi-permeable membrane [24].

2. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] is particularly adapted for monitoring fouling of the semi-permeable membrane [24].

3. The monitoring unit [10] according to claim 1 wherein the flow chamber [12] includes a feed fluid outlet [22] for permitting at least partial through-flow of the feed fluid through the flow chamber [12] such that cross-flow conditions apply in the flow chamber [12].

4. The monitoring unit [10] according to claims 1 and 3 wherein the flow chamber [12] is dimensioned such that a fluid pressure interval is defined intermediate the feed fluid inlet [14] and the feed fluid outlet [22].

5. The monitoring unit [10] according to claim 4 wherein the fluid pressure at the feed fluid outlet [22] is less than that at the feed fluid inlet [14] such that, in use, the feed fluid partly exits through the feed fluid outlet [22] of the flow chamber [12] and in part passes through the semi-permeable membrane [24].

6. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] comprises a fluid permeable support member [16] for supporting the semi-permeable membrane [24] in the flow chamber [12].

7. The monitoring unit [10] according to claim 6 wherein the support member [16] constitutes a base portion of the flow chamber [12], the arrangement being such that feed fluid entering the flow chamber [12] passes at least in part through the support member [16].

8. The monitoring unit [10] according to claims 6 and 7 wherein the support member [16] is of any suitable porous material such as high-density polyethylene, stainless steel, brass, finely woven fiber or the like.

9. The monitoring unit [10] according to claims 6 to 8 wherein the support member [16] include pores of pore sizes between 10 and 150 µm.

10. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] includes spacer means for spacing the semi-permeable membrane [24] from the support member [16] so as to provide a flow space between the membrane [24] and the support member [16], or between adjacent membranes on the support member [16].

11. The monitoring unit [10] according to claim 10 wherein the monitoring unit [10] accommodates different spacers that vary in thickness and shape, the arrangement being such that fluid dynamics of the feed fluid flowing across the semi-permeable membrane [24] are influenced through the use of different spacers.

12. The monitoring unit [10] according to claim 11 wherein the monitoring unit [10] includes either a spacer that is locatable intermediate the semi-permeable membrane [24] and the support member [16] that is similar to a permeate-side spacer generally used in construction of spiral wrap elements; and/or includes a feed-side spacer similar to that used in construction of spiral elements in use, wherein the feed-side spacer is locatable on top of the semi-permeable membrane [24].

13. The monitoring unit [10] according to claims 10 to 12 wherein adsorption kinetics of fouling substances in the feed fluid are affected by specific spacer configurations, the monitoring unit [10] thus including the potential

for evaluating spacer technology because of its potential to include different types of spacers.

14. The monitoring unit [10] according to claims 1 and 6 wherein the fluid outlet [18] is arranged in fluid communication with the support member [16] such that fluid that has passed through the membrane [24] and the support member [16] exits the monitoring unit [10] through the fluid outlet [18].

15. The monitoring unit [10] according to claim 14 wherein the fluid outlet [18] is arranged in fluid communication with a conduit for passing the fluid through the water purification system.

16. The monitoring unit [10] according to claims 1 and 6 wherein the inspection window [20] is oriented substantially parallel to and somewhat spaced from the support member [16], the arrangement being such that the flow chamber [12] is defined intermediate the support member [16] and the inspection window [20].

17. The monitoring unit [10] according to claim 16 wherein the inspection window [20] is of any suitable transparent material, such as plastics, Perspex, glass or the like material characterized therein that it can withstand a pressure of at least between 40 and 50 bar.

18. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] includes regulating means for regulating flow across the membrane, as well as fluid pressure in the unit, the regulating means being adapted to permit repeatable or standard conditions, such as a constant cross-flow velocity and fluid pressure.

19. The monitoring unit [10] according to claim 18 wherein the regulating means is at least one valve arranged for regulating the fluid pressure interval intermediate the feed fluid inlet [14] and the feed fluid outlet [22].

20. The monitoring unit [10] according to claim 19 wherein the monitoring unit [10] includes at least one feed fluid inlet valve operatively associated with the feed fluid inlet [14]; and at least one feed fluid outlet valve operatively associated with the feed fluid outlet [22] of the flow chamber [12].

21. The monitoring unit [10] according to claims 19 and 20 wherein the monitoring unit [10] includes at least one fluid outlet valve at the fluid outlet [18].

22. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] is operatively associated with pumping means for further manipulating fluid pressure in the monitoring unit [10].

23. The monitoring unit [10] according to claim 22 wherein the monitoring unit [10] is operatively associated with a positive displacement pump arranged in-line with the monitoring unit [10] and suitable for maintaining the fluid pressure interval intermediate the feed fluid inlet [14] and feed fluid outlet [22] of the flow chamber [12].

24. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] includes flow distribution means in the form of a manifold [28] dimensioned for preventing turbulence within the flow chamber [12] and for effecting homogenous fluid flow.

25. The monitoring unit [10] according to claim 24 wherein the monitoring unit [10] includes an inlet manifold [28.1] arranged intermediate the feed fluid inlet [14] and the flow chamber [12] for regulating flow of feed fluid into the flow chamber [12].

26. The monitoring unit [10] according to claim 24 wherein the monitoring unit [10] includes an outlet manifold [28.2] located intermediate the flow chamber [12] and the feed fluid outlet [22], the outlet manifold [28.2] being arranged such that it prevents areas of decreased flow in the flow chamber [12] so as to prevent preferential foulant adsorption or biological growth.

27. The monitoring unit [10] according to claims 25 and 26 wherein the manifolds [28.1; 28.2] are arranged so as to permit reverse flow through the monitoring unit [10] for evaluating the effectiveness of back flushing on removal of impurities adsorbed onto the membrane [24].

28. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] comprises a casing of stainless steel or the like suitable material, the casing including top cover means [30] and bottom cover means [32] that are releasably connected to each other in fluid-tight and pressure-tight engagement, the arrangement being such that the inspection window [20], flow chamber [12] and support member [16] are located substantially intermediate the top and bottom cover means.

29. The monitoring unit [10] according to claim 28 wherein the top cover means [30] comprises a metallic frame dimensioned so as at least partially to frame the inspection window [20]; and wherein the bottom cover means [32] comprises a metallic sheet recessed at least partially to accommodate the flow chamber [12], the support member [16] and the fluid outlet.

30. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] comprises the potential of simulating, in the monitoring unit [10], conventional fluid dynamics associated with a semi-permeable membrane [24] across the spacer means and support member [16] and is therefore

adapted for monitoring fouling of a semi-permeable membrane [24] during operation of a water purification system.

31. The monitoring unit [10] according to claim 30 wherein the monitoring unit [10] operates at a fluid pressure corresponding to that of the water purification system, and more particularly at a fluid pressure of between 40 and 50 bar.

32. The monitoring unit [10] according to claim 1 wherein the monitoring unit [10] is located inline with a conventional reverse osmosis water purification system.

33. The monitoring unit [10] according to claim 32 wherein the monitoring unit [10] is adapted for monitoring fouling of a semi-permeable spiral membrane [24] in a spiral reverse osmosis water purification system and is located intermediate a feed fluid tank and a spiral membrane plant of the spiral reverse osmosis water purification system.

34. A method of monitoring fouling of a semi-permeable membrane [24] in a water purification system, the method comprising the steps of providing a monitoring unit [10] comprising a flow chamber [12] having an inlet for permitting ingress of a feed fluid into the flow chamber [12], the arrangement being such that the membrane [24] is at least partly

supported in the flow chamber [12]; at least one fluid outlet arranged in fluid communication with the flow chamber [12] for permitting egress of fluid from the monitoring unit [10] after having passed through the membrane; and an inspection window [20] for permitting visual inspection of the semi-permeable membrane; placing at least one semi-permeable test membrane [24] on the fluid permeable support member; effecting at least partial passage of feed fluid through the test membrane; and visually monitoring fouling of the test membrane [24] through the inspection window [20] as an indicating means for determining fouling of the semi-permeable membrane [24] in the water purification system.

35. The method according to claim 34 wherein the method comprises the step of effecting at least partial passage of feed fluid through the membrane [24] under conventional system operating conditions such that fouling of the semi-permeable membrane [24] is monitored during operation of the water purification system.

36. The method according to claims 34 and 35 wherein the method particularly concerns monitoring fouling of a semi-permeable spiral membrane [24] in a spiral reverse osmosis water purification system.

37. The method according to claim 34 wherein the test membrane [24] is removably placed on the support member [16] and is spaced from the support member [16] by means of spacer means.

38. The method according to claims 34 and 37 wherein the test membrane [24] is any suitable flat-sheet semi-permeable membrane, such as a micro-filtration, ultra-filtration, nanno-filtration or the like reverse osmosis membrane, and in particular, is any type of flat-sheet semi-permeable membrane [24] associated with a polymeric support material used in the monitoring unit [10].

39. The method according to claim 34 wherein fouling of the test membrane [24] is also monitored by means of monitoring equipment, such as laser beam or infrared refraction, or sound acoustics.

40. The method according to claim 34 wherein flux or passage of pure water through the semi-permeable membrane [24] is measured by maintaining flow and pressure constant through the monitoring unit [10], the arrangement being such that any deviation in the flux through the membrane [24] is attributable to adsorption of impurities onto the membrane [24] (fouling or biofouling), which changes the permeability characteristic of the membrane [24].

41. The use of a monitoring unit [10] including a semi-permeable test membrane [24] for evaluating one or more of the following operating parameters in a water purification system, namely the efficiency of different types of chemicals utilized in the system, such as anti-scalants, biocides and anti-fouling chemicals; the effect of using different membranes and/or associated spacer means in the water purification system on the operating efficiency of the system; and efficiency of different membrane cleaning methods.

42. The use of a monitoring unit [10] for evaluating one or more of the following parameters in a spiral membrane reverse osmosis water purification system namely fouling of the spiral membrane; the efficiency of different types of chemicals utilized in the system, such as anti-scalants, biocides and anti-fouling chemicals; the effect of using different membranes and/or associated spacer means in the water purification system on the operating efficiency of the system; and efficiency of different membrane cleaning methods, wherein the monitoring unit [10] comprises a flow chamber [12] having an inlet for permitting ingress of a feed fluid into the flow chamber [12], the arrangement being such that the membrane [24] is at least partly supported in the flow chamber [12]; at least one fluid outlet [18] arranged in fluid communication with the flow chamber [12] for permitting egress of fluid from the monitoring unit [10]

after having passed through the membrane; and an inspection window [20] for permitting visual inspection of the semi-permeable membrane [24].

43. A water purification system including at least one water-cleaning unit, the water purification system characterized therein that it includes a monitoring unit [10] that comprises a flow chamber [12] having an inlet [14] for permitting ingress of a feed fluid into the flow chamber [12], the arrangement being such that the membrane [24] is at least partly supported in the flow chamber [12]; at least one fluid outlet arranged in fluid communication with the flow chamber [12] for permitting egress of fluid from the monitoring unit [10] after having passed through the membrane [24]; and an inspection window [20] for permitting visual inspection of the semi-permeable membrane [24].

44. The use of a monitoring unit [10] in a water purification system wherein the monitoring unit [10] comprises a flow chamber [12] having an inlet [14] for permitting ingress of a feed fluid into the flow chamber [12], the arrangement being such that a semi-permeable membrane [24] is at least partly supported in the flow chamber [12]; at least one fluid outlet [18] arranged in fluid communication with the flow chamber [12] for permitting egress of fluid from the monitoring unit [10] after having passed through the membrane [24]; and an inspection window [20] for permitting visual inspection of the semi-permeable membrane [24].